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Seasonal Fluctuations of Physicochemical Characteristics of Selected Wetlands of Kogi State, North Central, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Authors GUA and JCO designed the study, carried out the field and the laboratory analyses of the study. Authors JCO performed the statistical analysis, wrote and proof-read the manuscript. Authors IN, CAI, CUU and AEN managed the literature searches and wrote the protocols. All authors thoroughly proof read and approved the final manuscript.

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ABSTRACT

This study is aimed at determining the physicochemical characteristics of selected wetlands of Kogi State. From each sampled wetlands (Abu'ja and Egwubi), surface water was collected and examined for the following physicochemical parameters: hydrogen ion concentration, electrical conductivity, total dissolved solids and temperature (^0C) using Hanna meter. Dissolved oxygen was determined using dissolved oxygen meter. The data collected was analyzed using the Statistical Packages for Social Sciences version 20.0, Paleontological Statistics version 3.14 and Microsoft Office. Physicochemical parameters studied were not normally distributed from test of normality.

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They were compared using Man-Whitney U and Kruskal-Wallis H nonparametric tests for comparisons between two and more than two groups respectively. In Abu'ja wetland, the temperature for all the months were similar except for January and December which were significantly cooler ($p < 0.05$); pH was similarly constant except for January and August ($p < 0.05$). Dissolved solids ranged from 95 to 118 ppm with similar values between months except in March. Mean electrical conductivity ranged from 0.15 to 0.22 ms/cm. These values were similar between months in Abu'ja. Significant fluctuation occurred in dissolved oxygen on monthly basis. In Egwubi study station, temperature ranged from 20°C to 31 °C, significant difference occurred between January and May and between September and November ($p < 0.05$), pH was also similar between months. Dissolved solids ranged from 26 to 90 ppm. Electrical conductivity ranged from 0.2 to 0.14 ms/cm. Significant differences only occurred between April and August ($p < 0.05$). Dissolved oxygen was similar throughout the study period. Our result indicated that the essential minerals and other physiochemical parameters are widely distributed but some are not within the normal range of portable water for humans. Both study wetlands showed low pollution, organic waste in Abu'ja site may be handled by autochthonous bacteria and through self purification of the water body. Nutrient levels are high in wetland habitats as wetlands have rich biomes and support high level of biodiversity. The water is suitable for irrigation and livestock consumption. The presence of the plankton is a pointer to the fact that the two wetlands possess adequate water quality for establishment of great biodiversity.

Keywords: Season; fluctuations; physicochemical; characteristics; wetlands; Kogi State; Nigeria.

1. INTRODUCTION

Wetlands are very productive ecosystem, which help in the control of biological cycles, preservation of water quality, nutrient movement and sustenance of food chains [1]. Wetland is usually where the soil is saturated with moisture and such places could be covered by superficial pools of water. Water quality varies with the season, locality, nature of soil and rock it goes through [2]. Wetland has excellent biodiversity which makes for a biologically productive ecosystem globally [3,4,5]. There is paucity of information on the physicochemical attributes of the wetlands water bearing in mind their use in a wide range of activities in Nigeria and other African Countries. Countryside population the world over get water for domestic purposes from wetlands particularly throughout the arid periods [6]. Different discharges into the wetlands from several sources usually affects the microfauna and flora that inhabit them [7]. Wetlands are also useful as they minimize the negative effect of floods by serving as storage centers for flood water [7,8]. Wetlands could come with impurities like metals, organic and inorganic compounds introduced into the water possibly via industrial activities, mining and farming [9,10]. The geometrically rising burden of human population growth, resource utilization, urbanization and industrialization have resulted in dwindling of natural wetland ecosystems [5,11]. Good quality water accessibility is vital to prevent diseases and improve quality of life [12]. Water quality is important in structuring an ecosystem as it affects all organism and their environment [13]. The quality of water also depends on its source which includes rain, spring, river, lake and sea. The main parameters for determining water quality in Nigeria are dissolved oxygen, ammonia, nitrogen temperature, pH, biological oxygen demand, turbidity, and coliform counts [14]. To evaluate the ecology of a wetlands, its physico-chemical parameters are usually investigated. This study is geared towards determining the Seasonal fluctuations of physicochemical characteristics of selected wetlands of Kogi State, North Central, Nigeria.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted in Abu'ja wetland in Dekina Local Government area, and Egwubi seasonal wetland in Ejule, Ofu Local Government area of Kogi State. Kogi east experiences tropical hinterland type of climate, with high temperatures of 27 – 30°C. The highest temperature is obtained between the period of March and April, while the lowest temperature is obtained between the period of December and January. The annual rainfall is 100 -150cm, with duration of six to eight months. The relative humidity is high during the rainy season; this is about 80% during this period; whereas the relative humidity is low during the dry season, as low as about 5%. The dry season lasts for about five to six months. The atmosphere is usually cloudy during rainy season, as opposed to dryness and dust in dry season.

2.2 Study Design and Sampling

A total of 3 sample sites were marked out in each wetland; (site 1), water merging with vegetation (site2) open water body, and (site 3) vegetation around water, was selected for proper coverage. Each of the areas were visited twice each month during the study period between 8 -11am in the morning to take the physico-chemical parameters of the wetlands.

2.3 Physico-chemical Analysis of Water

During each of the monthly visit, water sample was taken in situ from each of the selected wetlands between 8 and 11 am. From each sampled wetlands, surface water was collected and examined for the following physico-chemical parameters: alkalinity and acidity (pH), electrical conductivity (EC) total dissolved solids (TDS) and temperature (^{0}C), using Hanna meter whereas dissolved oxygen was measured using dissolved oxygen meter.

2.4 Data Analysis

The data was analysed using the Statistical Packages for Social Sciences (SPSS) version 20.0, PAST (Paleontological Statistics) version 3.14 and Microsoft Office Excel. Data on physicochemical parameters were not normally distributed from test of normality. They were compared using Man-Whitney U and Kruskal-Walis H non-parametric tests for comparisons between two and more than two groups respectively. Relationship between physicochemical was assess using bivariate Spearman Correlation. As there were multiple significant relationships between physicochemical parameters at each of the study stations, dimension reduction was carried out using Principal Component Analysis (PCA). Level of significance was at $p < 0.05$.

3. RESULT

The overall physicochemical characteristics at Ab'uja and Egwubi are summarized in Table 1. Temperature and pH was significantly higher at Egwubi, while DS, EC and DO were significantly higher in Ab'uja ($p < 0.0001$).

At the Ab'uja station, temperature was largely stable. Temperature for all the months except January and December were similar, these two months were significantly cooler ($p < 0.05$). pH was fairly stable at the Ab'uja station monthly for the duration of the study, except between January and August when there was significant difference ($p < 0.05$). Monthly DS at the Ab'uja station range from 95 to 118 ppm (Table 2). However, DS level was largely similar between the months except in March. Mean monthly EC ranged from 0.15 to 0.22ms/cm. Monthly EC at the Ab'uja station was similar. There was a greater significant fluctuation of DO on a monthly basis. DO in the months of September to December appear to be lower than the months before.

Physicochemical characteristics of the stream at the Egwubi station were largely similar between the months. Mean monthly temperature ranged from 26.90 to 31°C. Except for significant difference between January temperature and those of May, September and November ($p < 0.05$), all other months had similar temperature. pH was also similar between the months. January had the least mean p^H of 5.05 ± 0.03°C (Table 3). DS ranged from 26 to 90 ppm. The least DS were recorded in months of March and April. Mean EC ranged from 0.02 to 0.14 ms/cm. But based on Kruskal-Wallis H test, monthly EC at Egwubi was largely stable as significant difference only occurred between April and August EC ($p < 0.05$). DO was similarly showed slight difference between the months at Egwubi station. No record of physicochemical characteristics of Egwubi was made in the month of February.

Monthly physicochemical characteristics were compared between the Ab'uja and Egwubi stations as presented in Tables 4 to 8. Temperature in the months of January, March, April and May were each significantly higher at Egwubi than Ab'uja for each respective month. Though temperature was higher at Egwubi for the remaining months of June to December, the difference was not significant ($p < 0.05$). pH followed a similar pattern as temperature when compared between the two stations. pH at Egwubi was higher compared to Ab'uja for each month except January and December (Table 5). pH at Ab'uja station was assigned mean rank of 6.50 compared to 2.00 for same month at Egwubi; the difference was highly significant $p = 0.024$. In the months of March, April, May and June, pH was significantly higher at Egwubi compared to Ab'uja station ($p < 0.05$). July to November pH was also higher at Egwubi but the differences were not significant ($p < 0.05$).

In each of the months there were more DS in the Ab’uja station. Though the difference in DS was only significant in the months of January, March, April, May and June ($p < 0.05$). In the months of July to December the higher DS at Ab’uja station were not significantly different compared to Egwubi ($p < 0.05$; Table 6).

EC similarly followed the same pattern as temperature, p^H and DS. Significant difference in EC between the stations only occurred in the months of January, March, April, May and June (Table 7). In these months EC was significantly low in Ab’uja station ($p < 0.05$). EC remained higher at Ab’uja station for the rest of the months, but the difference was not significant statistically ($p < 0.05$).

DO similarly follow the same pattern as other physicochemical parameters. Significant variation between the stations occurred in the months of January; March, April, May and June ($p < 0.05$). Mean rank for DO was higher at Ab’uja in all five months of January, March, April, May and June. In the months of July to December, DO concentration remained higher at Ab’uja but the difference was not significant ($p < 0.05$).

At the Abu'ja station, there are significant correlations of some physicochemical parameters. Temperature was negatively correlated with pH, DS and EC, but positively correlated with DO (Table 9). The correlation between temperature and DS (r_s = -0.622), EC (r_s = -0.469) and DO (r_s = 0.421) were significant ($p < 0.05$). pH was weakly correlated with all other physicochemical properties of the Abuja station considered (Table 9). DS was strongly correlated with EC and DO. DS correlated significantly and positively with EC (r_s = 0.407), but negatively with DO (r_s = -0.527). EC correlated significantly and negatively with DO (r_s = -0.743).

Principal component analysis (PCV) reduced the dimensions of correlation into a two component matrix. The first component accounted for 45.6% of entire variation in physicochemical characteristics of the stream at Abu’ja station. Component two accounted for 24.2%, thus both component explained 69.7% of variations in the physicochemical parameters. All five components were resolved into the first component. Under the first component, temperature and DO were negatively related to DS, EC and pH (Table 10). In the second component, only pH was strongly resolved into it; in addition, temperature and EC were other weaker explanatory variables.

The component matrix of the physicochemical parameters at Abu’ja station is shown in Figure 1. DS and EC appear to resolve into a cluster at the positive end along the horizontal plane, having very high values on the first component and approaching zero on the second. Temperature, DO and pH were on the negative plane of component 1. Temperature and pH also resolved strongly in opposite arms of component 2 (Fig. 1).

There were correlations between some of the physicochemical parameters at the Egwubi station (Table 10). Temperature was negatively and significantly correlated with DS (r_s = -0.430, $p < 0.01$), pH similarly was negatively but significantly correlated with DS (r_s = -0.352, $p < 0.05$) whereas EC was significantly and negatively correlated with DO (r_s = -0.499, $p < 0.01$).

The multiple correlations were resolved into two principal components from PCA. Both components accounted for 71.3% of entire variations in physicochemical characteristics at Egwubi station. DS, DO and EC were resolved strongly into component 1. DO was negatively related to the other two variables under this component (Table 12). Temperature and pH resolved strongly into the third component. The PCA biplot for these relationships is shown in Fig. 2.

Table 1. Overall physicochemical characteristics at Ab’uja and Egwubi

Parameter	Ab’uja	Egwubi	U	P
Temperature (°C)	25.50 ± 0.33 (28.13)	27.73 ± 0.17 (74.69)	2234	< 0.0001
pH	5.25 ± 0.01 (32.09)	5.52 ± 0.03 (69.60)	2020	< 0.0001
DS (ppm)	110.75 ± 1.02 (69.50)	50.86 ± 2.56 (21.50)	0	< 0.0001
EC ($_{m}S_{/cm}$)	0.19 ± 0.00 (68.82)	0.07 ± 0.01 (22.37)	37	< 0.0001
DO (mg/l)	6.89 ± 0.13 (62.72)	5.67 ± 0.09 (30.21)	366	< 0.0001

Values as mean ± Standard error (Mean Rank)

Table 2. Monthly physicochemical characteristics at Ab'uja station

Month	Temperature (°C)	pH	DS (ppm)	EC ($_{mS/cm}$)	DO (mg/l)
January	19.93 ± 0.14^{b}	5.3 ± 0.00^{a}	115.25 ± 0.57^{ab}	0.21 ± 0.00^{b}	6.45 ± 0.02^{abc}
February	26.48 ± 0.21^{a}	5.25 ± 0.02^{ab}	100.50 ± 1.11^{bc}	0.22 ± 0.00^{a}	6.45 ± 0.02^{abc}
March	26.80 ± 0.04^{a}	5.25 ± 0.02^{ab}	95.00 ± 1.19^{c}	0.16 ± 0.01^{c}	7.90 ± 0.03^{a}
April	26.78 ± 0.08^{a}	5.28 ± 0.02^{ab}	110.25 ± 0.17^{abc}	0.15 ± 0.00^{c}	8.00 ± 0.00^{a}
May	26.50 ± 0.03^{a}	5.23 ± 0.02^{ab}	115.25 ± 0.31^{ab}	0.18 ± 0.01^{bc}	7.90 ± 0.04^{a}
June	26.58 ± 0.04^{a}	5.25 ± 0.02^{ab}	112.75 ± 0.36^{abc}	0.18 ± 0.00^{bc}	6.75 ± 0.04^{abc}
July	26.45 ± 0.03^{a}	5.30 ± 0.00^{ab}	115.00 ± 0.00^{abc}	0.19 ± 0.00^{abc}	6.50 ± 0.00^{abc}
August	26.6 ± 0.00^{a}	5.15 ± 0.03^{b}	114.00 ± 0.00^{abc}	0.19 ± 0.00^{abc}	8.00 ± 0.00^{a}
September	26.45 ± 0.03^{a}	5.20 ± 0.00^{ab}	116.50 ± 0.29^{ab}	0.20 ± 0.00^{abc}	5.55 ± 0.00^{b}
October	26.65 ± 0.03^{a}	5.25 ± 0.00^{ab}	116.00 ± 0.00^{ab}	0.21 ± 0.00^{abc}	5.05 ± 0.03^{c}
November	25.95 ± 0.03^{a}	5.20 ± 0.00^{ab}	116.50 ± 0.29^{abc}	0.20 ± 0.00^{abc}	6.45 ± 0.03^{abc}
December	20.75 ± 0.14^{b}	5.35 ± 0.09^{ab}	117.50 ± 0.29^{a}	0.21 ± 0.00^{abc}	5.55 ± 0.03^{b}

Values as mean ± standard error. Values with different alphabet superscript within a column were significantly different ($p < 0.05$). Superscript attached based on Kruskal-Wallis H test.

Table 3. Monthly physicochemical characteristics at Egwubi station

Month	Temperature (°C)	pH	DS (ppm)	EC ($_{mS/cm}$)	DO (mg/l)
January	30.90 ± 0.23^{a}	5.05 ± 0.03^{b}	44.00 ± 0.00^{ab}	0.12 ± 0.00^{ab}	5.45 ± 0.03^{ab}
February	-	-	-	-	-
March	29.05 ± 0.03^{ab}	5.60 ± 0.00^{ab}	26.50 ± 0.29^{bc}	0.02 ± 0.00^{ab}	6.50 ± 0.00^{ab}
April	27.75 ± 0.18^{ab}	5.60 ± 0.03^{ab}	27.75 ± 0.79^{c}	0.03 ± 0.00^{b}	6.03 ± 0.24^{a}
May	27.03 ± 0.02^{b}	5.60 ± 0.00^{ab}	59.00 ± 8.29^{ab}	0.03 ± 0.00^{ab}	5.48 ± 0.21^{ab}
June	27.50 ± 0.00^{ab}	5.50 ± 0.03^{a}	52.75 ± 3.02^{ab}	0.04 ± 0.00^{ab}	5.95 ± 0.22^{ab}
July	27.00 ± 0.00^{ab}	5.65 ± 0.03^{ab}	47.00 ± 0.58^{ab}	0.04 ± 0.00^{ab}	5.50 ± 0.00^{ab}
August	27.15 ± 0.03^{ab}	5.60 ± 0.00^{ab}	47.00 ± 0.00^{ab}	0.14 ± 0.00^{a}	6.45 ± 0.03^{ab}
September	26.95 ± 0.03^{b}	5.55 ± 0.03^{ab}	58.50 ± 0.29^{a}	0.13 ± 0.00^{ab}	5.05 ± 0.03^{ab}
October	27.15 ± 0.03^{ab}	5.55 ± 0.03^{ab}	59.00 ± 0.00^{ab}	0.14 ± 0.00^{ab}	5.00 ± 0.00^{b}
November	26.90 ± 0.06^{b}	5.60 ± 0.00^{ab}	60.50 ± 0.29^{a}	0.14 ± 0.00^{ab}	5.50 ± 0.00^{ab}
December	28.50 ± 0.00^{ab}	5.25 ± 0.09^{a}	90.50 ± 0.29^{a}	0.11 ± 0.01^{ab}	5.05 ± 0.03^{ab}

Values as mean ± standard error. Values with different alphabet superscript within a column were significantly different ($p < 0.05$). Superscript attached based on Kruskal-Wallis H test.

Table 4. Comparison of monthly temperature (°C) between Ab'uja and Egwubi stations

Month	Ab'uja	Egwubi	U	P – value
January	19.93 ± 0.33 (3.50)	30.90 ± 0.40 (8.00)	18	0.024
February	26.48 ± 0.52	-	-	-
March	26.80 ± 0.04 (3.50)	29.05 ± 0.02 (8.00)	36	0.002
April	26.78 ± 0.08 (3.50)	27.75 ± 0.18 (9.50)	36	0.002
May	26.50 ± 0.03 (3.50)	27.03 ± 0.02 (9.50)	36	0.002
June	26.58 ± 0.04 (3.50)	27.50 ± 0.00 (9.50)	9	0.100
July	26.45 ± 0.03 (2.00)	27.00 ± 0.00 (5.00)	9	0.100

Month	Ab'uja	Egwubi	U	P – value
August	26.60 ± 0.00 (2.00)	27.15 ± 0.03 (5.00)	9	0.100
September	26.45 ± 0.03 (2.00)	26.95 ± 0.03 (5.00)	9	0.100
October	26.65 ± 0.03 (2.00)	27.15 ± 0.03 (5.00)	9	0.100
November	25.95 ± 0.03 (2.00)	26.90 ± 0.06 (5.00)	9	0.100
December	20.75 ± 0.14 (2.00)	28.50 ± 0.00 (5.00)	9	0.100

Values as mean ± standard error (mean rank), but comparison based on Mann-Whitney U test.

Table 5. Comparison of monthly pH between Ab'uja and Egwubi stations.

Month	Ab'uja	Egwubi	U	P – value
January	5.30 ± 0.00 (6.50)	5.05 ± 0.05 (2.00)	< 0.0001	0.024
February	5.25 ± 0.04	-	-	-
March	5.25 ± 0.02 (3.50)	5.60 ± 0.00 (8.00)	18	0.024
April	5.28 ± 0.02 (3.50)	5.60 ± 0.00 (9.50)	36	0.002
May	5.23 ± 0.02 (3.50)	5.60 ± 0.00 (9.50)	36	0.002
June	5.25 ± 0.02 (3.50)	5.50 ± 0.03 (9.50)	36	0.002
July	5.30 ± 0.02 (2.00)	5.65 ± 0.03 (5.00)	9	0.100
August	5.30 ± 0.00 (2.00)	5.60 ± 0.00 (5.00)	9	0.100
September	5.15 ± 0.03 (2.00)	5.55 ± 0.03 (5.00)	9	0.100
October	5.25 ± 0.03 (2.00)	5.55 ± 0.03 (5.00)	9	0.100
November	5.20 ± 0.00 (2.00)	5.60 ± 0.00 (5.00)	9	0.100
December	5.35 ± 0.09 (4.00)	5.25 ± 0.09 (3.00)	9	0.100

Values as mean ± standard error (mean rank), but comparison based on Mann-Whitney U test.

Table 6. Comparison of monthly DS (ppm) between Ab'uja and Egwubi stations.

Month	Ab'uja	Egwubi	U	P – value
January	115.25 ± 1.41 (6.50)	44.00 ± 0.00 (2.00)	< 0.0001	0.024
February	100.50 ± 1.11	-	-	-
March	95.00 ± 1.19 (6.50)	26.50 ± 0.29 (2.00)	< 0.0001	0.024
April	110.25 ± 0.17 (9.50)	27.75 ± 0.79 (3.50)	< 0.0001	0.002
May	115.25 ± 0.31 (9.50)	59.00 ± 0.29 (3.50)	< 0.0001	0.002
June	112.75 ± 0.36 (3.50)	52.75 ± 3.02 (9.50)	< 0.0001	0.002
July	115.00 ± 0.00 (5.00)	47.00 ± 0.58 (2.00)	< 0.0001	0.100
August	114.00 ± 0.00 (5.00)	47.00 ± 0.00 (2.00)	< 0.0001	0.100
September	116.50 ± 0.29 (5.00)	58.50 ± 0.29 (2.00)	< 0.0001	0.100
October	116.00 ± 0.00 (5.00)	59.00 ± 0.00 (2.00)	< 0.0001	0.100
November	116.50 ± 0.29 (5.00)	60.50 ± 0.29 (2.00)	< 0.0001	0.100
December	117.50 ± 0.29 (5.00)	90.50 ± 0.29 (2.00)	3.000	0.700

Values as mean ± standard error (mean rank), but comparison based on Mann-Whitney U test.

Table 7. Comparison of monthly EC (ms/cm) between Ab'uja and Egwubi stations.

Month	Ab'uja	Egwubi	U	P
January	0.21 ± 0.01 (6.50)	0.12 ± 0.00 (2.00)	< 0.0001	0.024
February	0.22 ± 0.00	-	-	-
March	0.16 ± 0.01 (6.50)	0.02 ± 0.00 (2.00)	< 0.0001	0.024
April	0.15 ± 0.00 (9.50)	0.03 ± 0.00 (3.50)	< 0.0001	0.002
May	0.18 ± 0.00 (9.50)	0.03 ± 0.00 (3.50)	< 0.0001	0.002
June	0.18 ± 0.00 (3.50)	0.04 ± 0.00 (9.50)	< 0.0001	0.002
July	0.19 ± 0.00 (5.00)	0.04 ± 0.00 (2.00)	< 0.0001	0.100
August	0.19 ± 0.00 (5.00)	0.14 ± 0.00 (2.00)	< 0.0001	0.100
September	0.20 ± 0.00 (5.00)	0.13 ± 0.00 (2.00)	< 0.0001	0.100
October	0.21 ± 0.00 (5.00)	0.14 ± 0.01 (2.00)	< 0.0001	0.100
November	0.20 ± 0.00 (5.00)	0.14 ± 0.00 (2.00)	< 0.0001	0.100
December	0.21 ± 0.00 (5.00)	0.11 ± 0.01 (2.00)	< 0.0001	0.100

Values as mean ± standard error (mean rank), but comparison based on Mann-Whitney U test.

Table 8. Comparison of monthly DO (mg/l) between Ab'uja and Egwubi stations.

Month	Ab'uja	Egwubi	U	P
January	6.45 ± 0.05 (6.50)	5.45 ± 0.05 (2.00)	< 0.0001	0.024
February	6.45 ± 0.02	-	-	-
March	7.90 ± 0.03 (6.50)	6.50 ± 0.00 (2.00)	< 0.0001	0.024
April	8.00 ± 0.00 (9.50)	6.03 ± 0.21 (3.50)	< 0.0001	0.002
May	7.90 ± 0.04 (9.50)	5.48 ± 0.21 (3.50)	< 0.0001	0.002
June	6.75 ± 0.14 (9.50)	5.95 ± 0.22 (3.50)	< 0.0001	0.026
July	6.50 ± 0.00 (5.00)	5.50 ± 0.00 (2.00)	< 0.0001	0.100
August	8.00 ± 0.00 (5.00)	6.45 ± 0.03 (2.00)	< 0.0001	0.100
September	5.55 ± 0.03 (5.00)	5.05 ± 0.03 (2.00)	< 0.0001	0.100
October	5.05 ± 0.03 (4.50)	5.00 ± 0.00 (2.50)	1.500	0.200
November	6.45 ± 0.03 (4.00)	5.50 ± 0.00 (3.00)	< 0.0001	0.100
December	5.55 ± 0.03 (5.00)	5.05 ± 0.03 (2.00)	< 0.0001	0.100

Values as mean ± standard error (mean rank), but comparison based on Mann-Whitney U test.

Table 9. Spearman correlation of physicochemical parameters at Ab'uja station

Parameter	Temperature (°C)	Ph	DS (ppm)	EC ($_{m}S_{/cm}$)	DO (mg/l)
Temperature (°C)	1.000	- 0.228	- 0.622**	- 0.469**	0.421**
pH		1.000	- 0.060	- 0.019	- 0.135
DS (ppm)			1.000	0.407**	- 0.527**
EC ($_{m}S_{/cm}$)				1.000	- 0.743**
DO (mg/l)					1.000

Table 10. Principal component matrix of physicochemical characteristics in Abu'ja station

Parameter	Component matrix Component 1	Component 2
Temperature (°C)	- 0.719	0.429
pH	0.324	- 0.879
DS (ppm)	0.598	
EC ($_{m}S_{/cm}$)	0.772	0.405
DO (mg/l)	- 0.839	
Initial Engenvalues		
Total	2.278	1.209
Variance (%)	45.560	24.176
Cumulative variance (%)	45.560	69.736

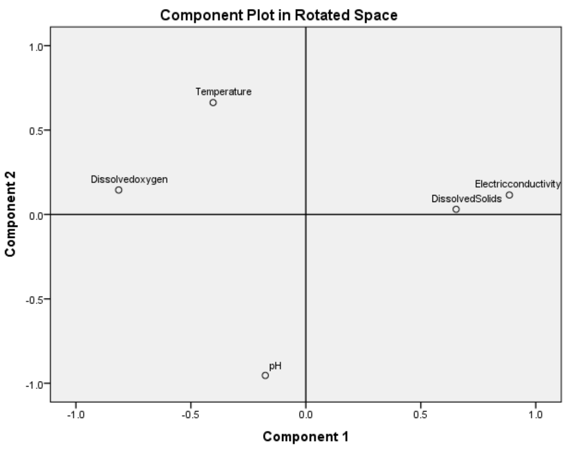

Fig. 1. Principle component plot (biplot) of physicochemical characteristics of Abu'ja station

Table 11. Spearman correlation of physicochemical parameters at Egwubi station

Parameter	Temperature (°C)	pH	DS (ppm)	EC (mS/cm)	DO (mg/l)
Temperature (°C)	1.000	- 0.243	- 0.430**	- 0.257	0.303
pH		1.000	- 0.352*	- 0.089	0.085
DS (ppm)			1.000	0.327*	- 0.430**
EC (mS/cm)				1.000	- 0.499**
DO (mg/l)					1.000

Table 12. Principal component matrix of physicochemical characteristics in Egwubi station

Parameter	**Component matrix**	
	Component 1	**Component 2**
Temperature (°C)		**0.828**
pH		**0.887**
DS (ppm)	0.841	
EC (mS/cm)	0.701	0.358
DO (mg/l)	-0.814	
Initial Engenvalues		
Total	1.917	1.618
Variance (%)	38.933	32.362
Cumulative variance (%)	38.933	71.294

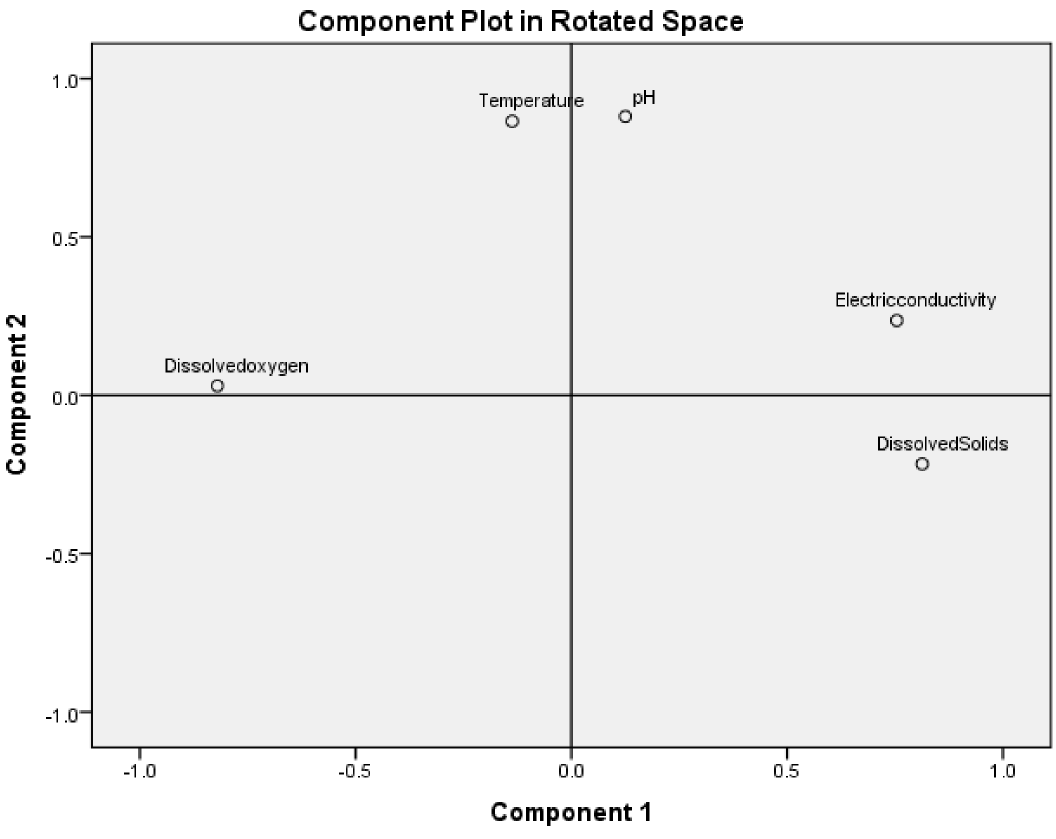

Fig. 2. Principle component plot (biplot) of physicochemical characteristics of Egwubi station

4. DISCUSSION

Temperature and pH were significantly higher at Egwubi wetland possibly due to the shallow depth, underlining rock and seasonal presence of water while DS, EC and DO were significantly higher in Abu'ja (P<0.0001). The observation in Abu'ja could be due to presence of dead organic matter submerged, and runoff water from Anyigba Township. The average pH value of 5.25 and 5.52 at Abu'ja and Egwubi respectively were lower than that reported by [1] of Ibo community wetland and the values are below the range recommended by standard organisation on Nigeria (2007) of pH 6.5 – 8.5 suitable for drinking water [15, 16, 17, 18. The total dissolved solids (TDS) values achieved in the study wetlands varied between 110.75 in Abu'ja and 50.86 in Egwubi, the differences depends on presence of much organic matter in the wetland and the intermittent clean up of the pond in Egwubi wetland. Both values obtained were below the limits of drinking water standards 500mg set by [15].

It is important to note that atmospheric oxygen enters the aquatic system by direct diffusion during shakeup of the surface. Dissolved oxygen (DO) is very important in water body and the main source of DO in water is atmosphere and by photosynthetic activity of aquatic plants. The amount of dissolved oxygen obtained for the studied wetlands are 6.89mg and 5.6 mg in Abu'ja and Egwubi respectively. This indicated that apart from atmospheric oxygen diffusion, many photosynthetic organisms abound in the permanent wetland than the seasonal wetland. The amount is below the limit (7.56—14.62 mg/l) for drinking water [15, 16, 17]. This higher value of DO obtained is an indication that autotroph load of the water body is higher in Abu,ja than Egwubi. It also indicates that many autotroph cannot establish fully before dry season interrupt in Egwubi wetland. The monthly fluctuation of DO was also a result of changes in the rainfall pattern. The lower DO recorded during September—December is as a result of change in temperature and atmospheric pressure and also a function of the Total Dissolved Solids in the water.

The electrical conductivity of wetland at Abu'ja station was comparatively higher than that of Egwubi wetland. This observation could be as a result of influx of runoff water from Anyigba township which increased the ionic concentration of the water body because of possible presence of some common ions of sodium, chlorine, calcium, and magnesium in the runoff water. However the EC of both wetlands is within the range of value for the portable water (0-800 $_u$s/cm. Generally it was observed that, the higher the water temperature the higher the pH for both wetlands.

5. CONCLUSION

Our result indicated that the essential minerals and other physiochemical parameters are widely distributed but some are not within the normal range of portable water for humans. Both wetlands showed low pollution, organic waste in Abu'ja site was possibly handled by autochthonous bacteria and through self purification of the water body. Nutrient levels are high in wetland habitats as wetlands have rich biomes and support high level of biodiversity. The water is suitable for irrigation and livestock consumption. The presence of the plankton is a pointer to the fact that the two wetlands possess adequate water quality for establishment of great biodiversity.. It was also noticed that plankton diversity increased as the water volume increased.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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